INSIDE
THE PVC PUMP

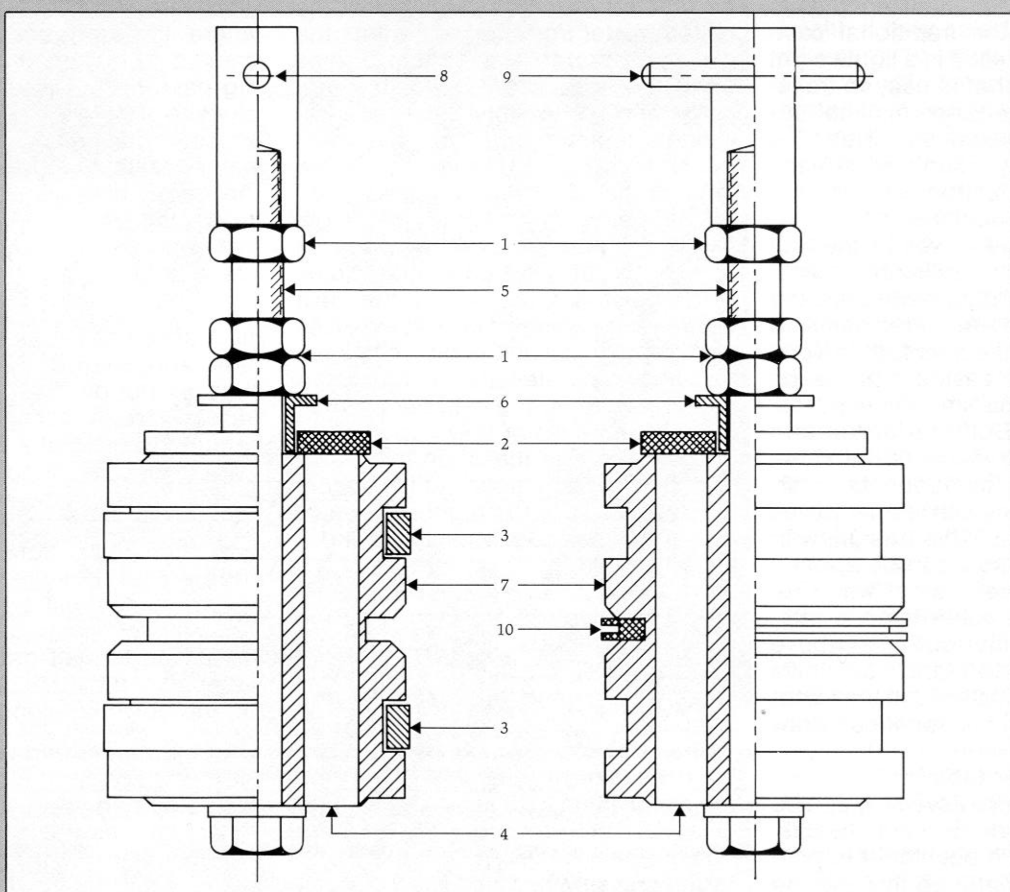
Handpump technology has changed little since Ctesibius developed a water lifting device for fire fighting in Alexandria circa 275 BC. The most commonly used type for community water supply is a piston pump, in which a piston moving up and down inside a cylinder creates a partial vacuum, and atmospheric pressure on the groundwater outside the pump cylinder pushes water up through the pump. The principle is the same as drinking water through a straw. Valves can be used to seal the piston so that it lifts the column of water trapped above it, while drawing more water into the foot of the column below it. While the piston valve is open, the foot valve is shut — and vice versa — in a reciprocal manner.

By the 1850s iron-bodied hand-operated reciprocating pumps were mass produced from standard designs — and opened new frontiers for agricultural development and settlements. But mechanization and electrification overtook the handpump, its market shrank, and interest in its development turned elsewhere. The handpump stopped evolving almost 50 years ago.

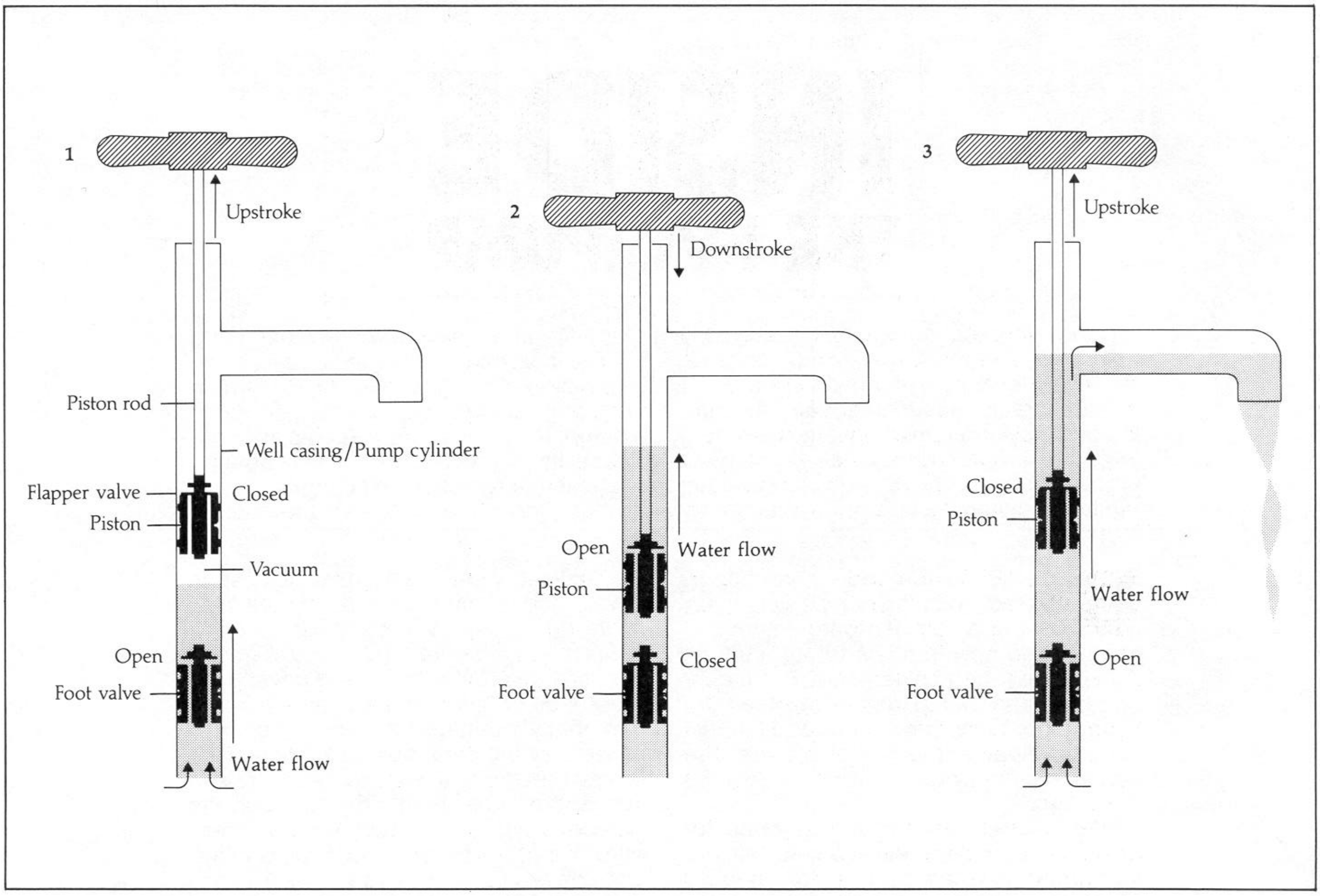
International assistance programs for rural water supplies created a new demand for rugged, low-cost pumps designed for simple troublefree operation and maintenance by local technicians. Experience taught some hard lessons: handpumps as they existed were not adapted for use in developing country villages, where they might be in use continually for up to 18 hours a day, worked by many different hands at different rates — and never get a drop of oil or have a nut tightened.

In many countries the most common cause of pump breakdown was wear of the seals that prevent water already raised from slipping between the piston and the cylinder walls during pumping. Success with an improved seal made from polyvinylchloride (PVC) plastic led to investigations of the other uses this material might have for pumps.

The search eventually led to a novel



(A) Piston assembly and (B) recoverable foot valve: (1) lock nuts; (2) valve flap (natural rubber); (3) piston rings (polyethylene); (4) six equally spaced holes; (5) bolt; (6) valve stop; (7) PVC plastic; (8) hole for connecting pin; (9) recovery pin; and (10) double-lip rubber seal



design that simplified the pumps mechanically, and substituted plastic pipe and moulded or milled plastic components for the traditional cast-iron or steel. The result is a lightweight but hardy pump that is easy to transport and install, requires minimal upkeep — and is inexpensive. Because many developing countries already produce PVC pipe for domestic use, the cost is reduced substantially.

A single PVC pipe serves as the well casing and pump cylinder. Inside, smaller diameter pipe serves as the piston rod, driving a moulded or milled plastic piston. A check or foot valve at the bottom of the casing pipe keeps the water from escaping on the pumping downstroke. Both the piston and the foot valve are made of the same interchangeable components: perforated plastic discs with flapper valves covering the holes. This design, with one simple alteration, can be applied to two different methods of water retrieval. Where the water table is relatively close to the surface, above 8 metres, the piston and foot-valve assembly can be installed in the pump body and through suction it can draw water upwards.

Where the water table is lower, the piston and foot-valve assembly can be installed below ground within the casing pipe. From this position it is possible to "lift" the water up through the pump. These two variations are termed "suction" and "lift," respectively.

The simplified diagram on page 7 illustrates the action of the pump. On the upstroke, the flapper valve on top of the piston is in the closed position, thereby allowing a partial vacuum to be created in the cylinder below the piston. Water from the well enters the cylinder through the bottom, forces open the flapper on top of the foot valve, and rushes into the space between the piston and foot valve to fill the vacuum (Fig. 1). On the downstroke, the increase in pressure forces open the flapper valve on top of the piston, allowing the air, followed by water, to flow up through the uncovered holes in the piston (Fig. 2). On the next upstroke, the weight of the water causes the flapper valve on the piston to shut, trapping the water above the piston and forcing it up the cylinder (or riser pipe) as more water flows up into the cylinder through the open foot valve (Fig. 3). With each motion of the piston, the water is raised to a higher level, and comes out the spout when the cylinder becomes full.

The mechanical process is the same in the "lift" type pump, but since the piston assembly is already in contact with the water, it is simply a matter of lifting a column of water standing on the piston.

The problem of leaking seals has been attacked by installing rings on the piston (akin to those that are found on automobile engines) that are forced against the cylinder wall to make a seal by the pressure of a small flow of water channelled behind them as the piston moves.

Deformities in locally produced PVC pipe, and the obstructions of joints in the longer lengths needed to reach water in Ethiopia, forced engineers there to abandon the rings. But they discovered that grooves in the piston where the rings might have gone created a pressure drop in water flowing past them. The drop slowed and blocked the flow between the piston and cylinder wall, in effect creating a water seal that naturally conformed to the irregularities in the pipe. In Sri Lanka, leather cup seals were used to overcome the same problem of pipe irregularities.

A second important failing of traditional pumps — breakage of the handles and their fulcrums from the stresses put on them by hard use — was solved by eliminating the lever handle in favour of a crosspiece grip like a bicycle handlebar attached directly to the pump rod. Pumping is simply a straight up-and-down lifting and pushing motion. It seems well adapted to developing countries, where women will pump with a vigorous motion like pounding grain in a mortar, and small children will grab either side of the handlebar and jump up and down helping one another.

Although it coped with many of the problems plaguing older designs, the PVC pump had to prove all its promise in actual use before engineers or villagers, wary of the latest technological fix, would accept it. IDRC embarked on an intensive global trial of the PVC pump, involving laboratory and field studies in Canada, England, Malaysia, Ethiopia, the Philippines, Sri Lanka, Thailand, and Malawi. □